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Psychological Monographs: General and Applied

Rigidity-Flexibility and Intelligence: A Cross-Sectional Study of the Adult Life Span from 20 to 70 Years[1]

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Recent thinking in the biological sciences, based on extensive case analyses in clinical medicine as well as searching actuarial studies of nationwide morbidity patterns, seems to indicate important relationships between certain behavior patterns and the decline in functional efficiency and structural maintenance of the human organism. From such a biological view, a trend seems to emerge which would view the normal aging process as a decrease in the excitability of tissue to stimuli, the organism being increasingly less able to adjust to the changes in reaction potential required by a given life situation (17, 28).

While a number of interesting physiological hypotheses for such a view might be considered at the molecular level, there is greater current concern at the molar level with types of explanation which require information on a multitude of purely psychological processes. In terms of the prediction of the rate and pattern of such molar change, psychological tools thus assume primary importance.

Until comparatively recent years, psychologists working in the developmental area have been primarily concerned with the periods of childhood and adolescence. Behavior theorists give considerable emphasis to a description of childhood behavior and of adolescent conflict, but take little or no cognizance of the conflicts, crises, and behaviorial changes of the adult life span. Excepting perhaps Erikson (6), no formal or theoretical discussion is to be found dealing with the phenomena of behavior change in the adult from the period of full maturity to senescent decline, even though descriptive and anecdotal material abounds.

In the present study a conceptual model for changes in adult behavior will be considered. Since this model is empirically derived, certain methodologies for its verification will be discussed and a major experiment dealing with age changes in intelligence, which bears on this model, will be described.

To begin with, it may be suggested that one way in which the human life cycle could be analyzed is to utilize the

[1] This monograph is based upon a doctoral dissertation at the University of Washington, Seattle (22). I owe much gratitude to Charles R. Strother and Paul Horst for their advice throughout the progress of this study. Acknowledgments need also be made to Read Tuddenham, Fred Rosenthal, and Ralph T. Granneberg who aided in various ways when the problem was first conceived. H. G. Gough permitted the use of his Rigidity Scale as part of our test battery with the cooperation of Consulting Psychologists Press, Palo Alto. The staff of Group Health Cooperative of Puget Sound were most cooperative in making available their records and assistance in drawing the sample of subjects. Specific acknowledgment should go to E. R. Clark, John Switzer, and Cecil Arnold. Finally, I want to express my gratitude to my wife without whose help and patience this study would have been impossible.

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concept of rigid and flexible behavior. A recent paper by Doerken (4), for example, suggests that the child starts out from a rather constricted environment, that during the period of maturation a widening of the child's constricted world occurs, and that, as a result of the increased opportunity of choice and an increasingly permissive environment, the individual generally reaches maturity as a rather flexible individual. From then on, the individual's "lifespace" again tends to constrict progressively until in old age a situation somewhat similar to early childhood experience is reached (3). Some authors further contend that possession of superior mental abilities may slow down the process of constriction and maintain that the higher an individual's intelligence the longer will he be able to function in a relatively flexible and functionally efficient manner (7).

If the above formulations are correct, one might be able to derive prediction equations from an empirical assessment of the rate of change in both intelligence and rigidity which could be used to some extent to make long-range predictions about the expected decline of an individual's functioning.

Proceeding a step further, one might examine some behavioral concomitants of test patterns indicative of flexible or rigid behavior at given age intervals. Such a procedure might suggest cut-off points for the prediction of functional efficiency and also aid the counselor in suggesting to his client the kind of activities that seem to be associated with flexible behavior and which ought to be encouraged to slow the constrictive process.

The present study is the culmination of a lengthy experimental program. In view of the dearth of material on behavioral change over the adult life span, it seemed necessary first to test and develop instruments which would be useful over a wide range of response both in terms of ability and age suitability. The first study in this program was conducted in 1951 (together with F. Rosenthal and R. M. Perlman) and was concerned with testing the suitability and reliability of the intermediate form of Thurstone's SRA Primary Mental Abilities test for older adults (26). The second more extensive study was concerned with the construction of an equally suitable battery for the measurement of behavioral rigidity and the assessment and validation of its factorial structure (21). With assurance in the usefulness of these devices, it was possible to proceed with the further analysis of adult behavior change.

A Conceptual Model for the Analysis of Age Changes in Adult Behavior in Terms of Rigidity-Flexibility

A hypothetical definition of aging has previously been suggested in terms of increasing resistance of the organism to behavioral or environmental change. This rather loose statement needs to be enlarged upon before one can deduce behaviorally verifiable consequences.

If one considers some of the conventional age gradients for many traits and abilities, one finds a fairly rapid rate of change during the early maturational period and a gradual slowing down as the developmental peak is reached and passed. From then on the developmental process is characterized by a gradual decrease in the effectiveness and personal adjustment of most individuals. Enough individual variation is found at each age level, however, to demand the introduction of additional explanatory factors.

If socially effective and mature be-

havior is taken to be a function of the individual's ability to adjust without difficulty to changes in the pattern of cognitive and social stimuli which make up his environment, one might then consider these individual differences to be an effect of a more or less complex interaction of initial potential ability and changing ability to utilize this potential for the acquisition of new behavior patterns.

If this formulation is correct, one might then go further to suggest that the individual who is most able to adjust to the stress imposed by changes in the patterns of environmental stimuli will tend to respond in a socially effective manner longer than his less flexible peer. Given reasonably constant environmental conditions it might be possible to measure a person's ability to adjust to change, once he reaches maturity, and to predict his personal gradient of decline in effective behavior.

The important question arises, however, as to what kind of maturational gradient this presumably central factor of ability to adjust to change may have. The impact of the postulated central factor would obviously depend upon the form which its age gradient might take. Alternate hypotheses will be proposed to explain age changes in behavior which are suggested by some of the most likely forms of such a gradient, but first it will be useful to consider how the ability to adjust to change might best be defined for purposes of measurement.

The class of behavior which has been closely studied in the past and which approximates fairly well the psychological aspects of adjustment to change has usually been subsumed under the heading of "behavioral rigidity." While there are almost no studies of a developmental nature dealing with rigidity, a great amount of work has been done to investigate the dimensions of this concept as well as to demonstrate their relation to specific personality configurations and to patterns of normal and abnormal behavior.[3]

In an earlier paper, it was found necessary to formulate a summary definition for the many concepts advanced as criteria of such behavioral rigidity. Behavioral rigidity was there defined as:

> . . . a tendency to perseverate and resist conceptual change, to resist the acquisition of new patterns of behavior, and to refuse to relinquish old and established behavior patterns (21).

This definition may seem rather broad, but a set of behavioral consequences can readily be deduced which are amenable to observational test.

From such a definition one can deduce, for example, that a rigid person dislikes to change patterns of interpersonal relationships, has difficulty in changing from one activity to another, is less efficient in activities requiring alternation and continuous readjustment of motor activities, etc.

It was shown elsewhere (19) that a battery of tests could be constructed to cover a great variety of operations subsumed under the above definition of behavioral rigidity. As the result of a series of factor analyses (21) it was further possible to show that this concept could best be described by a three-dimensional system. In terms of the tests on which high loadings for the three factors in this system were found, these dimensions were named "motor-cognitive rigidity," "personality-perceptual rigidity," and "psychomotor speed." An inspection of the nature of the tests high on these factors indicate

[3] Surveys of the literature on different aspects of the concept of "rigidity" may be found in papers by Werner (33) and by Levine (15); see also (22).

that they just about cover the gamut of psychological views on behavioral rigidity.

In terms of the operations specified by the tests identifying these factors the following definitions seem appropriate: The motor-cognitive rigidity factor seems to indicate the individual's ability to shift without difficulty from one activity to another; it is a measure of effective adjustment to shifts in *familiar* patterns and to continuously changing situational demands. The personality-perceptual rigidity factor seems to indicate the individual's ability to adjust readily to *new* surroundings and change in cognitive and environmental patterns; it seems to be a measure of ability to perceive and adjust to *unfamiliar* and *new* patterns and situations. The psychomotor speed factor finally indicates an individual's rate of emission of familiar cognitive responses. A high score on this factor would seem to imply superior functioning efficiency in coping with familiar situations requiring rapid response and quick thinking.

As a result of these studies some other "hunches" emerged which led to further preliminary investigations. For example, when the records of a sample of 216 subjects were rescored in terms of these derived factors, it was possible to show that rigidity in terms of all three factors increases with age in a manner similar to most conventional age gradients. An analysis of variance of two groups of 20 subjects, one aged below 25 and the other above 55, showed significant differences on all three factors at the 1% level of confidence. Furthermore, there appeared to be a significant correlation with an "intelligence" factor also extracted in the factor analysis (19). Great variation was found, however, among individuals, so that many old individuals were found both "intelligent" and "flexible," while some young individuals were found who were rigid.

This line of inquiry suggests that the level of functioning of an individual with respect to cognitive and perhaps other behavior traits may be predictable in terms of a more central factor which might be measured by a three-dimensional rigidity factor system and possibly well approximated by a composite score formed by a linear combination of the three factor scores.

Such a formulation might also be useful for the prediction of adult age changes in various types of socially important behavior classes, provided it can be shown that not only level of functioning, but maintenance of basal level of functioning over the adult age span can be meaningfully related to this central factor.

It was therefore felt desirable to draw a reasonably large sample, stratified cross-sectionally across the major portion of the adult age range, to assess changes in the degree of behavioral rigidity noted for successive age samples, and, further, to inquire what the relation of this variable might be with other important variates at various age intervals.

Since the maintenance of intellectual ability is of such paramount importance in socially effective behavior, and because of the positive relationship found in the preliminary studies, it was decided to concentrate upon an analysis of the relationship between behavioral rigidity and Thurstone's Primary Mental Abilities throughout the major portion of the adult age span. Such an inquiry has both practical and theoretical implications. For both, however, one must study the form of the age gradients as well as their interrelation to gain more insight as to where the crucial points of behavioral change might lie.

It has been stated earlier that the pre-

dictions which can be made about behavior change from a knowledge of performance on the rigidity variables will depend largely upon the form of the maturational changes shown by these variables. Depending on the form of this gradient it will be possible to examine four alternatives, which are listed here in descending order of predictive potency:

I. Behavioral age changes are a function of the individual's lack of ability to adjust to change and can thus be predicted for an advanced age from a knowledge of his standing on the rigidity-flexibility dimension at the basal age.

II. Behavioral age changes occur concomitantly with decreasing adjustment to change, and the level of function for individuals at any given age level is therefore predictable from knowledge of the rigidity-flexibility dimension.

III. Behavioral age changes and changes in rigidity-flexibility show no significant relation whatsoever.

IV. A further alternative must be considered when Proposition I is falsified, i.e., lack of ability of an individual to adjust to change may be a function of some other behavior variable and may be predictable for his old age from a knowledge of that variable at the basal age.

An empirical description of the rate of change observed on the variables to be measured is of interest in any event; although, in terms of prediction, the second alternative would be less powerful, the third trivial, and the fourth would be disproof of our basic assumptions.

In line with the previous discussion it is timely now to state more precisely the hypotheses concerning the influence of behavioral rigidity upon the specific case of changes in the mental abilities with age:

Case I. If there is a random distribution on the rigidity-flexibility dimension for each level of ability at the age of developmental peak and if age changes in ability are a function of the scores on the rigidity-flexibility dimension, then one should find zero or modest correlation between rigidity and intelligence at the basal age with a systematic increase of correlation for successive age groups. There will be a family of gradients of decline for each level of ability (the steepest gradient prevailing for the most rigid members) resulting in the mean values for the flexible members of a group remaining relatively constant while those for the rigid members would drop. In symbolic form:

$$BYf = BYr$$
$$\text{but } BOf > BOr$$

where BYf is the mean of ability measures for the young flexible members of the sample, BYr is the mean of ability measures for the young rigid members of the sample, BOf is the mean for the old flexible members, and BOr the mean for the old rigid members of the sample. The analysis of covariance may be used to test formally the validity of the first hypothesis.

Case II. If age changes in the mental abilities occur concomitantly with those in rigidity-flexibility, then either will serve to predict to some extent the level of functioning of the other at any given age level; and one should find significant but constant correlation throughout the adult age range influenced only by sampling variation and perhaps showing a slight drop towards the older end due to the effect of attrition. In this case the mean values for both the flexible and rigid members of the sample will show a consistent drop over the age range, but on the measures of ability there will be a significant but not increasing difference between the rigid and flexible members of the group at each age level, with the flexible members scoring in the positive direction. Again in symbolic form:

$$BYf > BYr$$
$$\text{and } BOf > BOr$$

The analysis of variance and covariance will be the appropriate test also for the second hypothesis.

Case III. If there are concomitant age changes in both rigidity-flexibility and the mental abilities but no significant relation exists, then the analysis of variance should verify the null hypothesis that rigid and flexible individuals do not differ in level of ability and the analysis of covariance should show that there is no relationship between differences on the rigidity-flexibility dimension and the age changes in mental abilities. In symbolic form it may be stated then that for this alternative:

$$BYf = BYr$$
$$\text{and } BOf = BOr$$

Case IV. Since this is the falsification of Case I, it requires identical conditions, viz.: If there is a random distribution on each mental ability for each level of rigidity-flexibility at the basal age and if age changes in rigidity-flexibility are a function of the scores on the Primary Mental

Abilities, then one should find zero or low correlations between rigidity and intelligence at the basal age with systematic increase of correlation for successive age groups. The mean rigidity-flexibility values for the highly able will remain relatively constant while the scores for those of low ability will drop. In symbolic form:

$$RYh = RYl$$
$$\text{but } ROh > ROl$$

where RYh is the mean of rigidity-flexibility measures for the young highly intelligent members of the sample, RYl the mean for the young people of low intelligence, ROh for the old highly intelligent, and ROl for the oldsters of low intelligence. The analysis of covariance will again be the appropriate test.

Further discussion of the implications of these hypotheses is reserved until after the empirical evidence is examined. The method and sample of subjects used to investigate these propositions will next be described.

The Test Material

The Assessment of Behavioral Rigidity

As already mentioned, it was decided to utilize the results of an earlier inquiry (**19, 21**), concerned with determining the dimensions of behavioral rigidity, in providing the measures of rigidity for the present study. In these earlier studies a battery of tests of rigidity, some of which were selected from the literature and others of which were newly constructed, had been factor analyzed. Since developmental studies were anticipated, the final test battery retained only those tests which appeared applicable to young adults as well as mature and senescent populations. For practical reasons, the battery was further restricted to tests suitable for group administration and an effort was made to retain those tests where social status and educational level were of minimal importance in influencing test results.

The factor analysis of these tests, using a modified version of the multiple-group method (12), resulted in the isolation of three factors termed motor-cognitive rigidity, personality-perceptual rigidity, and psychomotor speed. The factorial structure of the test battery was further cross-validated by drawing a new sample and factoring the correlation matrix for this sample. The oblique factor loadings for both analyses (reported in 21) were very similar and indicate rather stable structure for the hypothesized dimensions.

The original test battery was shortened by deleting the two tests which contributed the lowest factor loadings to their respective factor scores. The remaining four subtests yield seven scores and require about 30 minutes for administration. The following paragraphs give a brief description of the Test of Behavioral Rigidity (hereafter called TBR).[4]

1. The Capitals Test. The *S* copies a paragraph first as it is printed on a sample card and then once more, substituting capitals for lower case letters and vice versa; e.g. Original: "The Duke DREW his sword." Second time: "tHE dUKE drew HIS SWORD." Two and one-half minutes are allowed for each part, and an estimate of rigidity is obtained by dividing the number of correctly written words in the test series by the number of correctly written words in the practice series. The number of words in the practice series is used as one of the psychomotor speed estimates.

2. The Opposites Test. This test contains three series of 40 stimulus words each. In the first series, the *S* is required to respond by giving the opposite of the words listed. In the second list, he responds with a synonym of the word listed. The last list finally presents a mixture of stimuli to which *S* must respond either with the synonym or the antonym. When the stimulus word is printed in capitals, the synonym is required; while when small letters are used, the antonym is the required response. The number of correct responses on the first two series gives another psychomotor score. Two rigidity scores are yielded by this test. The first measures accurate cognitive shift and is based on the third series only. It is given by dividing the number of rigid (i.e. inappropriate) responses by the total number of responses given on this series. The second rigidity score measures the influence of rigidity in inhibiting rapid cognitive shift and is given by the formula: number of correct re-

[4] Copies of the test booklet and the manual of instructions for administration and scoring have been deposited with American Documentation Institute. Order Document No. 5573, remitting $2.00 for 35-mm microfilm or $3.75 for 6-by-8 in. photocopies.

sponses in the third series divided by one-half the number of correct responses in Series 1 and 2. Two minutes are allowed for each series.

3. Scale of Rigidity (R scale). This is a 22-item scale of general statements which Gough (8) found to be empirically related to rigid behavior. These items are mixed among 44 masking items which in themselves can be scaled as a measure of social responsibility (10). The score is the number of flexible responses favorably endorsed by the *S*.

4. The Rigidity Index (P scale). This is a 9-item inquiry as to rigid modes of behavior. It contains questions like: "Do you feel strongly inclined to finish whatever you are doing in spite of being tired of doing it?" The score is also the number of flexible responses. (In the test booklet the *P* scale appears as items 151-159 of the Scale of Rigidity.)

The Capitals Test was adopted from Bernstein's extensive study of quickness and intelligence (2) and is representative of the "functional" or Spearmanian approach to the study of perseveration and rigidity. The Opposites Test was newly constructed by the writer, along lines suggested by the work of Scheier and Ferguson (27). All the items of the R scale were obtained from Gough's California Psychological Inventory (9), although some of the statements and the arrangement of items were modified for use throughout the adult age range by Schaie and Rosenthal (25). The Rigidity Index, finally, was adapted by the writer by means of Guttman scale analysis technique (11) from a 17-item scale first used by Lankes (14).

The present battery meets one of the most common criticisms of rigidity tests (16, 32) by recording two separate scores in the tests where speed is at issue. The first score on the Capitals and the Opposites Tests (termed the "non-rigidity"—NR—score) represents performance on a practice series and turns out to be a good estimate of the psychomotor speed dimension. The second score is the "rigidity" score, i.e. the score indicating the amount of interference resulting when rigid behavior inhibits adjustment to the altered condition.

In computing the rigidity scores on the tests where time limits were imposed, a correction formula was applied to allow for irrelevancies introduced into some of the tests due to motor speed and difficulty of alternation. Since the influence of specific test function has been allowed for by the two separate scores, these artifacts may be corrected simply by scoring the ratio between the number of responses on the practice and the test series. To permit uniform interpretation this scoring system is so arranged as to assign high scores for flexible and low scores for rigid performance.

TABLE 1

WEIGHTS USED FOR TRANSFORMING DEVIATION SCORES ON THE TBR SUBTESTS TO FACTOR SCORES

	Motor-cognitive rigidity	Personality-perceptual rigidity	Psychomotor speed	Composite rigidity
1. Capitals-R	.25			.083
2. Capitals-NR			.60	.200
3. Opposites 1	.35			.117
4. Opposites 2	.40			.133
5. Opposites-NR			.40	.133
6. *R* scale		.50		.1665
7. *P* scale		.50		.1665

Once the factorial structure of the test battery was known to be essentially three dimensional, it was possible to write appropriate regression equations to permit an estimate of factor scores from knowledge of the test scores of subjects on the original variables having high loadings on the specified factors. The deviation scores for the subtests may then be appropriately weighted and combined to yield factor scores. Since two estimates of factor loadings were available (see 21), a rounded-off average was taken to provide the regression weights for the purpose of constructing transformation tables for the revised test battery. These weights are given in Table 1.

Since rigidity scores were to be assigned such that they would be easily comparable to other tests, it seemed convenient to write them in the form of standard scores with a Mean of 50 and an *SD* of 10 (a further transformation to a "rigidity quotient" form with a Mean of 100 and an *SD* of 15 is given in the manual of instruction).[4]

The weights for the composite rigidity score represent a simple additive linear combination. This weighting was used for computational simplicity since a least-squares approximation was shown to be only negligibly better when multiple correlations between the three factor scores and a composite IQ score were computed.

While norms were available for various population samples (20), it was decided to apply the above mentioned transformation to the deviation scores computed on the basis of the present study, since it provides a larger and more representative sample than any of the previously used populations.

The Assessment of Mental Abilities

One of the common criticisms of tests of intelligence has been the lack of readily identifiable subtest meaning and the high subtest intercorrelations. It was felt that while the Wechsler-Bellevue, for example, may be a useful measuring device for clinical purposes, there are other research tests of more clear-cut factorial structure which, in addition to a global intelligence score, would also yield relatively independent estimates of distinct mental abilities.

Thurstone's Primary Mental Abilities Test, Intermediate Form (hereafter called PMA) (30) seemed the best instrument for the purposes of this study. Extensive normative research has been done on this test with adolescents and previous work has indicated its applicability to a sample of *Ss* aged 53-78 years (26). The test contains relatively little material related to formal education and thus seemed well suited for this study. The PMA test battery was derived by factor analysis of about 60 mental tests, resulting in the isolation of several distinguishable mental abilities (29). A test was then constructed to measure each of these abilities and their relative independence was demonstrated in further investigations by low intercorrelations (13).

The PMA test battery consists of five subtests designed to cover the presumably independent factors listed below with the description furnished in the test manual (31).

1. Verbal-Meaning (V) is the ability to understand ideas expressed in words. It is used in any activities in which information is obtained by reading or listening to words.

2. Space (S) is the ability to think about objects in two or three dimensions. It is perhaps best described as the ability to imagine how an object or figure would look when it is rotated, to visualize objects in two or three dimensions, and to see the relations of an arrangement of objects in space.

3. Reasoning (R) is the ability to solve logical problems—to foresee and plan. It is probably the most important of the mental abilities. The person with good reasoning ability can solve problems, foresee consequences, analyze a situation on the basis of past experience, and can make and carry out plans according to recognizable facts.

4. Number (N) is the ability to work with figures—to handle simple quantitative problems rapidly and accurately. It involves primarily speed and accuracy in handling numbers.

5. Word-Fluency (W) is the ability to write and talk easily. It differs from Verbal-Meaning because it concerns the speed and ease with which words can be used, rather than with the degree of understanding of verbal concepts.

In addition to the factor scores it is possible to obtain a composite IQ equivalent score by summing the subtest scores according to the formula:

$$\text{Composite} = V + S + 2R + 2N + W$$

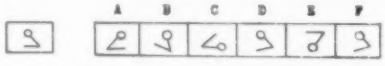
The differential weights, according to Thurstone, were assigned in inverse proportion to the standard deviation of the tests to give each test approximately equal importance.

The following paragraphs describe the material used in the PMA subtests:

VERBAL-MEANING is measured by a test made up of the following type of item:

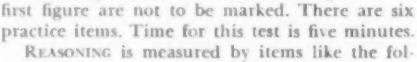
ANCIENT: A. Dry B. Long C. Happy D. Old. The word which means the same as the first word is to be marked. There are 5 practice items and 50 test items. Four minutes are allowed for this test.

SPACE is measured by 20 items similar to the one below:



Every figure in the row that is the same as the first figure, even though it is rotated, is to be marked. Figures that are mirror images of the first figure are not to be marked. There are six practice items. Time for this test is five minutes.

REASONING is measured by items like the following:



The letters in the row form a series based on a rule. The problem is to mark the letter that should come next in the series. The test is made up of 10 practice items and 30 test items, and the time limit is six minutes.

NUMBER is measured by a test with items of the following kind:

The sum of each column of figures is given, but some of the solutions are right and others

are wrong. Five practice items and 60 test items are given, with a time limit of six minutes.

WORD-FLUENCY is measured by a test requiring the writing of as many words beginning with a certain letter as possible in a specified time. The letters S or M are usually used and the time limit is five minutes.

Since the test was originally constructed for a high school age population, Schaie, Rosenthal, and Perlman (26) were concerned whether the high reliability and low intercorrelation data claimed for the test by its authors would hold up for an adult sample. Their results indicate that the factors presumably measured by the tests remained equally independent for an old adult group. They also obtained reliability data by administering the test as a power test and obtained reliability coefficients ranging from .94 to .96, indicating that the PMA is a stable test also for old adults.

Norms for the PMA are available only for a high school population. It was therefore decided to transform all obtained scores as well as the composite IQ score into standard scores with Means of 50 and *SD*s of 10, based upon the observed distribution of our own sample.

All test material was administered in a group testing situation. Twenty-four testing sessions were held in classrooms at the University of Washington and in various public schools throughout the King County area. Attendance at these sessions varied from about 15 to 45 examinees, with one examiner and one proctor. The testing sessions lasted approximately two hours and were handled in a standard manner.

SUBJECTS

Subjects for this study were obtained in the course of a cooperative research project from the membership of a prepaid medical plan. The total pool of potential *Ss* over 16 years of age available from this organization consisted of about 18,000 members. A stratified random sampling procedure picked the names of 2,818 potential *Ss* who were then contacted and asked to volunteer. In response to this request positive replies were obtained from 451 men and 459 women, a total of 910 *Ss*.[5] Due to conflicting time schedules and other sources of attrition, such as incomplete test records, the final sample consists of 500 *Ss* ranging in age from 20 to 70 years. The sample was divided into ten 5-year intervals, each containing 25 men and 25 women.

As seems inevitable in studies employing volunteer *Ss*, there was a tendency for the better educated levels of the pool of potential *Ss* to participate. In spite of this fact a great range of educational background was found. In the sample, 11.0% of the *Ss* had no more than a grade school education, 42.4% had attended or completed high school, 32.6% had attended or graduated from college, and 14.0% had done some postgraduate work in addition to their college education. The Mean number of years of education was 12.7 for the male and 13.0 for the female *Ss*. In terms of age differences, Mean number of years of schooling varied from 11.0 years for the 61-65 year-old group, which was lowest, to 14.1 years for the 26-30 year-old group. These differences are significant but would seem to reflect the increased educational opportunities available for the younger *Ss*, rather than differences in the population from which the *Ss* were obtained, since these changes run pretty close to the general census data. It should be noted, though, that the mean educational level for all subgroups is somewhat above that of the general population.

All *Ss* were rated as to their occupational level on a scale ranging from 0 to 9 using the major classifications of the United States Census Bureau, ranging from "unskilled labor" to "professional." Where the occupation "housewife" was given, the occupational rating of the husband was used. On this rating scale, the sample attained a Mean rating of 6.0 which is higher than the population average but is probably quite close to the population distribution in a metropolitan area like Seattle, where one would find a larger proportion of skilled mechanics, clerical workers, and professionals than would be true for the population average. According to this classification, the sample contains: 1.2% unskilled laborers, 0.8% employed in domestic service, 3.6% operatives, 5.0% employed in the service occupations, 5.8% in the protective services, 13.6% skilled craftsmen, 33.0% in sales or clerical work, 16.6% at the managerial or proprietary level, 15.2% engaged in semiprofessional and 5.2% in professional occupations. The Mean occupational levels for different age groups vary from 5.2 to 6.4 points. These age differences show a systematic trend, achieving a peak in the 46-

[5] A more complete description of the known characteristics of the sample population as well as its relationship to the parent pool from which it was drawn will be published elsewhere.

50 year period and showing some decline thereafter.

All participants indicated their total family income on a rough 6-point scale. On this scale, 6.6% of the sample had a total family income below $2,000, 18.8% were in the interval $2,000 to $4,000, 41.8% in the $4,000 to $6,000, 18.2% in the $6,000 to $8,000, 10.4% in the $8,000 to $10,000, and 4.2% in the above $10,000 brackets. The Mean income level for the entire group was equivalent to a total annual family income of about $4,500.

Since the source of *Ss* was a family medical plan, most of them are found to be married with a sprinkling of single, widowed, and divorced persons. In the sample, 6.6% of the group were single, 85.0% married, 2.6% divorced, and 5.8% had been widowed. The distribution of marital status is homogenous with respect to age, except for the youngest group (where there is a high incidence of people presumably before the stage of establishing families) and in the oldest groups (where evidence is found of family dissolution through the death of one of the partners).

From the above descriptive characteristics it would appear that the cross-sectional sample is reasonably representative of the broad middle group of our population. The sample is not quite as representative for the lowest and highest population segments, but in terms of the socioeconomic characteristics given is probably an adequate sample of the upper 75% of the American social structure. This is probably as good a population sample as can be constituted without the use of captive populations.[5]

Results

Age Changes in Mental Abilities and in the Measures of Rigid Behavior

After all test records had been scored as prescribed by the examiner manuals (31, Footnote 4), the resulting raw scores were key punched into IBM cards. Means and standard deviations for the total sample, and separately for the ten 5-year age groups, were computed on the IBM Type 604 Calculating Punch according to methods described by Lunneborg, Wright, and Ax (18). All raw scores were then converted into standard *T* scores with a Mean of 50 and an *SD* of 10, the statistics for the total sample being used as point of reference, which in view of the sample size would seem to give relatively stable estimates of the universe parameters. As a result, mean scores in the subsequent tabulations are comparable between different variables as well as between different age subsamples. New means and *SD*s were then computed for the subgroups and graphs were plotted to show the resulting age gradients.[6]

1. Age changes in the measures of behavioral rigidity. As was indicated in the section on the test material, the TBR version used in this study yields seven different subtest scores which, when combined according to appropriate weighting formulae, will yield three factor scores and a composite rigidity score which is a linear combination of these factor scores. Table 2 gives the means and *SDs* for the factor scores for each of the subgroups. Figure 1 gives the age gradients which result in graphic form.

Figure 1 and Table 2 indicate systematic age changes on all the rigidity dimensions. Analysis of variance tests show differences between age groups to be significant at the 1% level of confidence for every variable. It may thus be concluded, on the basis of these data that people do become more rigid with increasing age on all the dimensions of rigidity measured.

To give a better view of the extent of change in these scores, the absolute decrement in *T* scores from the mean score of the most flexible group has been

[6] In studying the following graphs and tables the reader might wish to keep in mind that differences between subgroups are significant if they exceed 2.63 *T*-score points at the 1% level and if they exceed 1.98 *T*-score points at the 5% level of confidence.

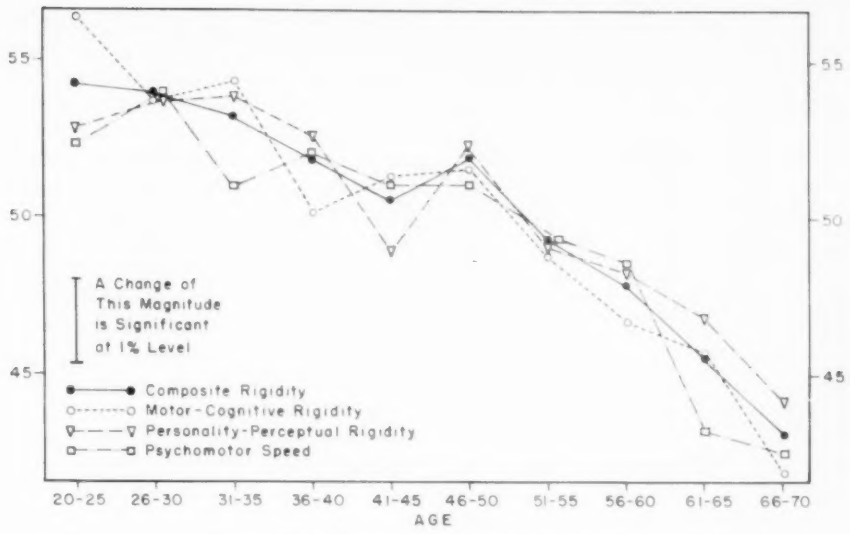


FIG. 1. Age changes in the measures of rigid behavior.

plotted for all groups. These are shown in Table 3 and Figure 2. It appears that the most dramatic decline is found on the motor-cognitive rigidity dimension, while the least (though still highly significant) change occurs on the personality-perceptual dimension. Significant decrements at the 1% level of confidence prevail for the motor-cognitive rigidity dimension already for the 26-30 year old group. On the personality-perceptual rigidity dimension, however, the decrement is not significant until the 41-45 year old group is reached. On the psycho-

TABLE 2

AGE CHANGES IN THE COMPOSITE RIGIDITY, MOTOR-COGNITIVE RIGIDITY, PERSONALITY-PERCEPTUAL RIGIDITY, AND PSYCHOMOTOR SPEED SCORES

Age	Composite rigidity		Motor-cognitive rigidity		Personality-perceptual rigidity		Psychomotor speed	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
20–25	54.08	4.39	56.48	5.10	52.78	7.25	52.24	7.60
26–30	53.88	4.93	53.66	5.20	53.60	6.77	53.94	9.32
31–35	53.14	4.68	54.30	4.95	53.68	7.27	50.94	7.66
36–40	51.68	6.04	50.04	7.42	52.52	7.77	51.98	9.91
41–45	50.54	5.39	51.20	6.25	48.82	7.43	51.02	7.61
46–50	51.88	5.25	51.52	7.25	52.40	6.96	51.00	7.95
51–55	49.26	5.26	48.72	7.72	49.06	7.22	49.32	8.16
56–60	47.90	5.84	46.66	7.39	48.30	8.85	48.53	8.85
61–65	45.50	4.78	45.02	7.71	46.86	6.40	43.44	7.37
66–70	43.10	5.50	41.88	7.77	44.14	6.38	43.00	7.57

Note.—A high score on the rigidity variables means that this is a score in the *flexible* direction. It should also be noted that the statistics in this and all subsequent tables and graphs are based on a subgroup *N* of 50 for each group, consisting of 25 men and 25 women.

TABLE 3

ABSOLUTE MEAN DECLINE IN FLEXIBILITY WITH AGE IN *T*-SCORE POINTS FROM THE MEAN SCORE OF THE MOST FLEXIBLE SUBGROUP

Age	Composite rigidity	Motor-cognitive rigidity	Personality-perceptual rigidity	Psychomotor speed
20–25	—	—	0.90	1.70
26–30	0.20	2.82	0.08	—
31–35	0.94	2.18	—	3.00
36–40	2.40	6.44	1.16	1.96
41–45	3.54	5.28	4.86	2.92
46–50	2.20	4.96	1.28	2.94
51–55	4.82	7.76	4.62	4.62
56–60	6.18	9.82	5.38	5.40
61–65	8.58	10.86	6.82	10.50
66–70	10.98	14.60	9.54	10.94

motor speed dimension, significant decrement is noted at age 31-35; and finally, on the composite rigidity scores, significant decrement is noted beginning with the 36-40 year old group.

From these data it would appear that loss of flexibility would become noticeable in the forties and fifties, and that by the fifties an average loss of approximately one population *SD* has occurred. In terms of the dimensions tested it appears then that, whether by maturational change or environmental effect, there is a progressive and significant decrement with age in the ability of the average adult to react to environmental change.

Correlations were also computed, separately for each age group, among the factor scores and between the factor scores and the composite score. These and all subsequent correlations shown were computed by means of IBM equipment using a modification of Schaie's standard score method (**18, 23**). Table 4 does not seem to show any significant age trends in these intercorrelations.

2. *Age changes in mental abilities.* All PMA raw scores were converted into *T* scores to make them comparable to the rigidity scores, again using the mean and *SD* of the whole sample as the point of reference. A composite equivalent score was obtained by use of Thurstone's formula (already described) and converted into *T*-score form. Table 5 lists the means and *SD*s for each of the five mental abilities which were measured as well as for the composite IQ scores. Figure 3 shows the age gradients which result when the data in Table 5 are plotted. The ages given on these graphs are the midpoints of the subgroups.

Age changes on all five mental abilities, as well as on the composite IQ, are found to be significant at the 1% level of confidence. It will be noted, however, that the form of these gradients differs among the individual abilities. The peak level of performance is, with the exception of Reasoning, found at a later level

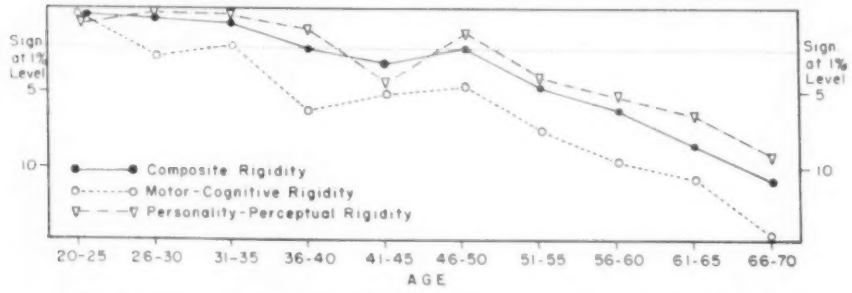


FIG. 2. Mean decrement in flexibility on all rigidity measures (in *T*-score points from mean of most flexible subgroup).

TABLE 4

INTERCORRELATIONS FOR THE FACTOR SCORES ON THE TEST OF BEHAVIORAL RIGIDITY AND THEIR CORRELATION WITH THE COMPOSITE RIGIDITY SCORE

Age	MCR-PPR	MCR-PS	PPR-PS	Comp-MCR	Comp-PPR	Comp-PS
20–25	−.04	.20	.24	.48	.68	.78
26–30	.24	.30	.13	.65	.61	.79
31–35	.06	.17	.35	.47	.74	.80
36–40	.18	.36	.26	.69	.65	.80
41–45	.21	.47	.36	.70	.73	.82
46–50	.04	.39	.39	.67	.64	.85
51–55	.10	.34	.10	.71	.56	.74
56–60	.32	.08	.31	.62	.79	.69
61–65	−.01	.50	.01	.77	.44	.79
66–70	.24	.38	.42	.74	.70	.80

than is suggested by comparable studies with other intelligence tests. On the composite IQ score, the peak level is reached by the 31-35 year old group. The peak levels of performance for the individual abilities are: Verbal-Meaning, 31-35 years; Space, 26-30 years; Reasoning, 20-25 years; Number, 46-50 years; and Word-Fluency, 31-35 years.

These findings indicate a wide range in the age trends for specific mental abilities. Since all the peak levels appear in the period from 20 to 50 years, this differential rise and decline of abilities might help to explain the tendency for global intelligence scores, when plotted against age, to show minimally significant decline for the period of the middle years and then, about age 50, to show steeper decrements.

The absolute decrement in *T*-score points from the mean peak levels for each of these abilities is shown in Table 6. Figure 4 also presents this comparison of differential age changes graphically. It may be seen that there is variability not only in age of peak performance, but also in the age level at which a significant decrement from the peak level is first noticed. Thus it may be noted that, for the composite IQ score, a significant decrement is first observed for the 36-40 year old group. The ages for the individual mental abilities at which significant decrements are first seen are: Verbal-Meaning, Space, Reasoning and Word-Fluency, 36-40 years; while for Number it does not occur until age 56-60.

TABLE 5

AGE CHANGES ON THE PRIMARY MENTAL ABILITIES

Age	Verbal-Meaning		Space		Reasoning		Number		Word-Fluency		Composite IQ Score	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
20–25	51.40	8.15	54.80	11.38	56.24	8.82	47.52	9.89	50.05	9.37	51.90	9.46
26–30	55.35	8.10	55.93	9.93	55.93	8.53	50.57	9.15	51.10	10.44	54.25	9.18
31–35	55.50	8.13	55.27	9.38	55.39	8.99	52.37	9.83	53.69	8.56	55.35	9.23
36–40	52.82	11.20	52.97	7.93	52.45	9.74	51.33	10.71	50.62	8.93	52.43	9.15
41–45	52.57	8.49	50.99	9.38	53.02	7.95	52.34	9.31	52.78	9.74	53.08	8.07
46–50	52.29	9.17	50.07	9.82	50.30	9.17	53.26	10.38	52.37	9.60	52.39	9.54
51–55	49.13	8.79	47.79	9.40	48.39	9.10	52.12	10.00	51.25	9.51	50.10	8.96
56–60	46.61	9.76	45.23	10.58	45.39	8.36	50.11	8.77	49.25	9.37	47.04	8.70
61–65	43.03	8.21	45.40	8.51	42.05	7.10	45.08	8.90	45.23	11.14	42.55	8.31
66–70	41.34	7.93	41.60	7.48	40.88	5.86	45.30	8.75	43.70	8.21	40.88	7.44

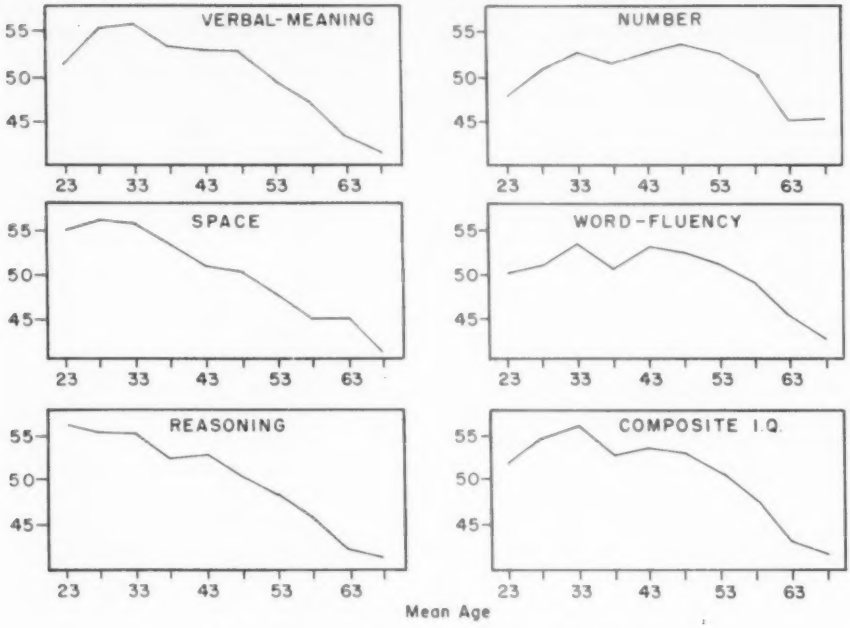


FIG. 3. Age changes in the Primary Mental Abilities.

More variation is shown in the rate of decrement. If decrements are assumed to become behaviorally noticeable if they have a magnitude of 5 points (½ *SD*) and marked if they exceed 10 points (1 *SD*), then these findings would indicate that such decline becomes *noticeable* at the following age levels: Verbal-Meaning, 51-55; Space and Reasoning, 46-50; Number and Word-Fluency, 61-65; and total IQ, 51-55. Decrement in the mental abilities according to above criterion would be considered *marked* at the following ages: Total IQ, 61-65; Space and Reason-

TABLE 6

ABSOLUTE MEAN DECREMENT IN *T*-SCORE POINTS FOR THE PRIMARY MENTAL ABILITIES FROM MEAN PEAK LEVEL

Age	V	S	R	N	W	IQ
20–25	4.10*	1.13	—	5.74*	3.64*	3.45*
26–30	0.15	—	0.31	2.69*	2.59	1.10
31–35	—	0.66	0.85	0.89	—	—
36–40	2.68*	2.96*	3.79*	1.93	3.07*	2.92*
41–45	2.93*	4.04*	3.22*	0.92	0.91	2.27
46–50	3.21*	5.86*	5.94*	—	1.32	2.96*
51–55	6.37*	8.14*	7.85*	1.14	2.44	5.25*
56–60	8.89*	10.70*	10.85*	3.15*	4.44*	8.31*
61–65	12.47*	10.53*	14.10*	8.18*	8.46*	12.80*
66–70	14.16*	14.33*	15.36*	7.96*	9.99*	14.47*

* Significant at the 1% level of confidence.

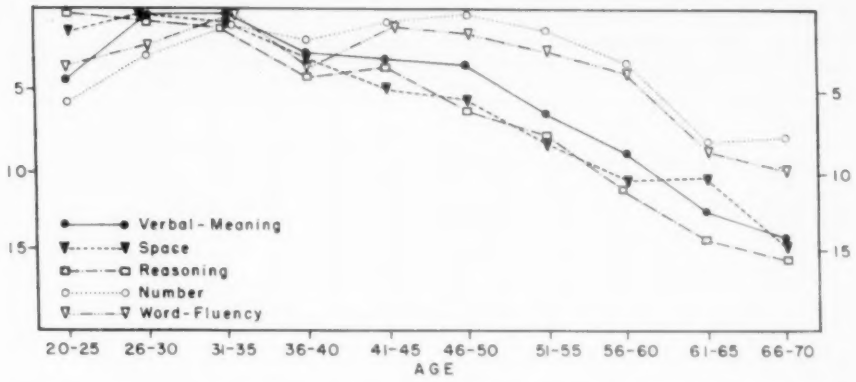


FIG. 4. Mean decrement in the Primary Mental Abilities from mean peak levels (in *T*-score points). (Significant at 1% level = 2.63; at 5% level = 1.98.)

ing, 56-60; Verbal-Meaning, 61-65; and Number and Word-Fluency probably in the seventies, if these age trends continue systematically.

Another matter of interest is the degree of variability shown by individuals among their different mental abilities. So that variability could be discerned, it was decided to compute for each *S* the variance of his PMA scores about his own mean. These variances were then normalized and transformed into *T* scores. Table 7 gives the mean variability for the different age groups. This table shows that there is a slight but significant tendency for intra-individual variability to increase with age and reach a peak at age 41-45. There is some decline in variability with the older groups, but this decline was not significant at the 1% level of confidence. These findings seem to agree to some extent with Balinsky's factorial study of the subtests of the Wechsler-Bellevue at various age levels, in which the variability was found to increase towards the middle years and then show decline (1). The peak level of variability was shown by Balinsky to be at age 25-29, however, and the decline in variability found by him was more marked than in the present study.

To shed more light on the problem of shifts in intra-individual differences with age, and the possible relationship of such changes to the "rigidity-flexibility" model, subtest intercorrelations were computed. Table 8 gives the intercorrelations of the subtests separately for each age group, and Table 9 lists the correlations between the individual mental abilities and the composite score.

If one considers average intercorrelations for each age level, the lowest relation is found at ages 36-45; but other shifts are not systematic enough to allow

TABLE 7

AGE CHANGES IN INTRA-INDIVIDUAL VARIABILITY ON THE PMA

Age	Mean	*SD*
20–25	48.99	6.91
26–30	48.62	7.60
31–35	48.28	7.17
36–40	49.99	10.16
41–45	51.68	11.19
46–50	48.95	9.56
51–55	49.85	11.18
56–60	50.60	11.84
61–65	50.49	10.73
66–70	50.50	9.59

TABLE 8

INTERCORRELATIONS OF THE PRIMARY MENTAL ABILITIES

Age	V-S	V-R	V-N	V-W	S-R	S-N	S-W	R-N	R-W	N-W	Average
20–25	.28	.50	.47	.45	.42	.39	.43	.56	.58	.64	.472
26–30	.47	.71	.50	.46	.53	.39	.35	.59	.51	.42	.493
31–35	.49	.75	.57	.45	.46	.57	.18	.61	.52	.45	.505
36–40	.20	.51	.47	.53	.21	.09	.02	.56	.46	.38	.343
41–45	.21	.52	.37	.58	.39	.33	.18	.52	.33	.11	.354
46–50	.33	.71	.43	.64	.49	.36	.39	.44	.50	.44	.473
51–55	.45	.69	.31	.44	.56	.27	.39	.53	.39	.31	.434
56–60	.15	.66	.49	.53	.24	.18	.30	.42	.54	.53	.404
61–65	.31	.55	.41	.47	.33	.40	.38	.30	.54	.39	.408
66–70	.13	.54	.53	.26	.35	.49	.16	.80	.48	.32	.406

further conclusions. No systematic shifts are noted in the relationship between the individual abilities and in the composite IQ score.

The Relation Between the Changes in Behavioral Rigidity and Mental Abilities: Results of the Correlation Analysis

After considering the age changes in both rigidity and mental ability measures, the next step in the analysis of the experimental evidence is concerned with changes in the relationship between the two sets of measures. Correlations were therefore computed between the composite rigidity score and the PMAs as well as between the individual TBR factor scores and the PMAs.

The reader should be reminded here of the hypotheses submitted earlier. Hypothesis I stated that:

> Behavioral age changes are a function of the individual's lack of ability to adjust to change and can thus be predicted for an advanced age from a knowledge of his standing on the rigidity-flexibility dimension at the basal age.

If this hypothesis were correct, the correlations between the TBR and the PMA would be expected to increase systematically with age. Hypothesis II stated that:

> Behavioral age changes occur concomitantly with decreasing adjustment to change and the level of function for individuals at any given age level is therefore predictable from knowledge of [either] . . . dimension.

If this hypothesis were true one would expect to find significant but constant correlation throughout the adult age range, with possibly slightly decreasing values towards the upper end of the range. Hypothesis III stated that:

> Behavioral age changes and changes in rigidity-flexibility show no significant relation whatsoever.

In this case insignificant correlation throughout the adult age range would be expected. Hypothesis IV, finally, is the obverse of Hypothesis I. It stated that:

> Lack of ability of an individual to adjust to change may be a function of some other behavior variable and may be predictable for his old age from a knowledge of that variable at the basal age.

Again correlations between PMA and TBR would be expected to rise with age and the direction of the relation would

TABLE 9

CORRELATIONS BETWEEN THE PRIMARY MENTAL ABILITIES AND THE COMPOSITE IQ SCORE

Age	V	S	R	N	W
20–25	.66	.64	.79	.86	.82
26–30	.77	.67	.85	.81	.72
31–35	.80	.67	.84	.88	.67
36–40	.77	.32	.80	.82	.68
41–45	.74	.57	.78	.76	.61
46–50	.78	.63	.80	.79	.78
51–55	.72	.60	.84	.76	.67
56–60	.77	.47	.77	.79	.81
61–65	.71	.62	.71	.77	.79
66–70	.67	.56	.88	.90	.61

TABLE 10

CORRELATIONS BETWEEN THE COMPOSITE RIGIDITY SCORE AND THE PRIMARY MENTAL ABILITIES

Age	V	S	R	N	W	IQ
20–25	.50	.26	.63	.42	.55	.61
26–30	.67	.35	.68	.56	.50	.71
31–35	.69	.39	.52	.51	.49	.65
36–40	.60	.27	.63	.67	.52	.80
41–45	.75	.27	.52	.44	.48	.69
46–50	.71	.25	.53	.48	.60	.67
51–55	.58	.37	.58	.29	.54	.61
56–60	.49	.15	.56	.36	.63	.60
61–65	.35	.00	.44	.11	.32	.32
66–70	.59	.18	.47	.44	.38	.66

TABLE 12

CORRELATIONS BETWEEN THE PERSONALITY-PERCEPTUAL RIGIDITY SCORE AND THE MENTAL ABILITIES

Age	V	S	R	N	W	IQ
20–25	.31	.06	.20	.08	.24	.21
26–30	.31	.02	.24	.10	.12	.19
31–35	.42	.21	.27	.25	.25	.34
36–40	.30	.20	.30	.37	.27	.42
41–45	.40	.23	.30	.18	.23	.40
46–50	.36	−.09	.17	.31	.16	.27
51–55	.12	.19	.18	.05	.14	.16
56–60	.21	.13	.32	.16	.36	.32
61–65	−.12	−.14	−.08	−.06	−.09	−.12
66–70	.18	.05	.09	.08	−.02	.10

be testable by means of the analysis of covariance.

Tables 10-13 give the intercorrelations between the composite rigidity score and the TBR factor scores with the composite IQ as well as the individual PMA scores, and Figure 5 shows a graphic representation of the age gradients for the correlations between the rigidity scores and the composite IQ measure.

Figure 5, as well as the data in Tables 10-13, indicate that there is a general tendency for these correlations to be significant and to be relatively constant over the adult age range, except for a slight drop in the older age groups. Correlations for samples of the magnitude here used are significant at the 5% level of confidence if they exceed .27 and at the 1% level of confidence if they exceed .35.

While the changes in the relation between rigidity and the PMAs are fairly consistent, they are by no means uniform for the different rigidity dimensions or the individual mental abilities. It should be noted that the personality-perceptual rigidity score shows lower correlation with the PMAs throughout, and at the top end of the age range seems to have no relation at all to the global intelligence score. This is in contrast to the motor-cognitive rigidity and the psychomotor speed scores, which correlate significantly with the PMAs throughout.

Since the composite rigidity score appears to show, on the whole, the highest correlations with the individual PMA

TABLE 11

CORRELATIONS BETWEEN THE MOTOR-COGNITIVE RIGIDITY SCORE AND THE PRIMARY MENTAL ABILITIES

Age	V	S	R	N	W	IQ
20–25	.18	.31	.31	.27	.32	.37
26–30	.53	.42	.03	.33	.25	.53
31–35	.40	.56	.30	.40	.13	.44
36–40	.39	.20	.47	.47	.29	.54
41–45	.54	.25	.28	.38	.33	.52
46–50	.60	.30	.46	.24	.01	.56
51–55	.54	.42	.53	.22	.31	.51
56–60	.18	.04	.30	.05	.27	.22
61–65	.34	.14	.47	.11	.41	.38
66–70	.60	.19	.35	.35	.25	.56

TABLE 13

CORRELATIONS BETWEEN THE PSYCHOMOTOR SPEED SCORE AND THE PRIMARY MENTAL ABILITIES

Age	V	S	R	N	W	IQ
20–25	.46	.18	.70	.49	.50	.61
26–30	.50	.32	.55	.62	.57	.70
31–35	.58	.18	.50	.41	.54	.56
36–40	.57	.19	.57	.58	.54	.72
41–45	.68	.14	.49	.44	.51	.65
46–50	.56	.25	.50	.47	.51	.61
51–55	.49	.14	.47	.32	.61	.55
56–60	.62	.14	.56	.48	.68	.68
61–65	.45	.02	.48	.14	.30	.36
66–70	.52	.14	.58	.52	.52	.64

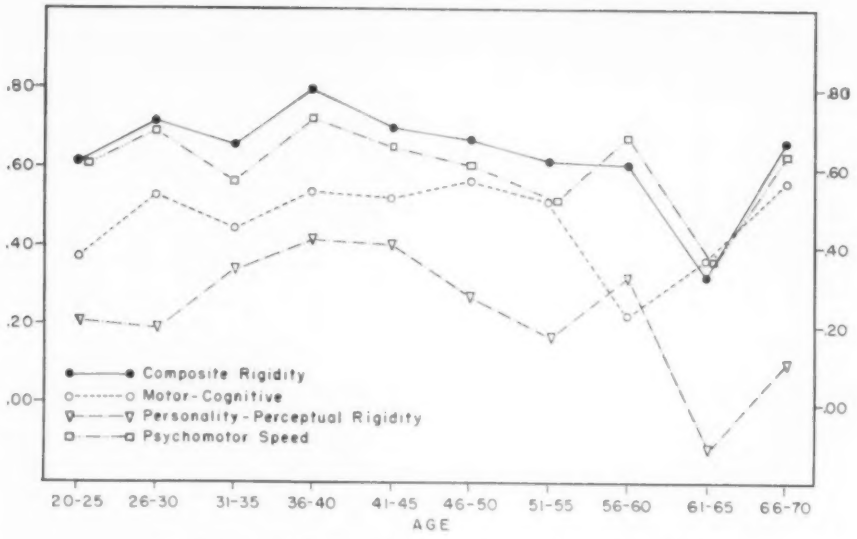


FIG. 5. Correlation between TBR scores and PMA composite IQ.

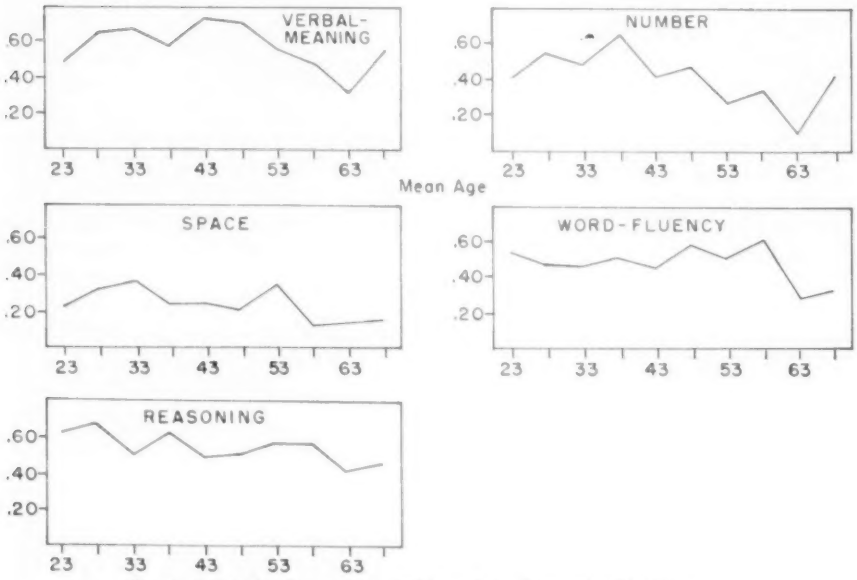


FIG. 6. Correlation between the PMAs and the Composite Rigidity score.

TABLE 14

CORRELATION OF YEARS OF EDUCATION WITH THE TBR AND PMA SCORES

Age	MCR	PPR	PS	COMP	V	S	R	N	W	IQ
20–25	.03	.24	.33	.35	.45	.22	.20	.35	.23	.40
26–30	.37	.16	.47	.50	.51	.27	.59	.38	.25	.51
31–35	.14	.27	.50	.48	.50	.16	.34	.40	.22	.42
36–40	.51	.34	.52	.64	.66	.16	.47	.50	.59	.69
41–45	.44	.13	.30	.38	.24	.11	.20	.04	.16	.19
46–50	.30	.23	.47	.51	.59	.19	.40	.13	.40	.41
51–55	.44	.04	.72	.62	.63	.16	.53	.37	.45	.58
56–60	.17	.38	.60	.56	.43	−.01	.58	.43	.48	.54
61–65	.30	.04	.54	.44	.40	.10	.40	.21	.26	.36
66–70	.38	.19	.52	.54	.54	.19	.59	.48	.37	.59

scores, its relationship with each of the individual mental abilities has been plotted in Figure 6. It will be noted that the correlations are again significant over the entire age range, except for Space, with some apparent decrease in the correlations with age. The slopes and levels of these age gradients, however, differ among the abilities, with little or no significant drop in the correlations with Reasoning and Word-Fluency, fairly marked drop for Verbal-Meaning and Number, and relatively low or insignificant correlation with Space.

On the basis of the preceding results it appears that Hypotheses I and IV are not tenable, while, with the possible exception of the relationship with Space, evidence favorable to Hypothesis II has been presented. A more formal statistical test of these hypotheses will be presented in the next section concerned with the results of the analyses of variance and covariance.

Before proceeding further, some of these relationships should be re-examined with respect to another variable. It was noted in the description of the sample that there were some tendencies for the older age groups to show a somewhat lower mean level of education as is characteristic of the general population. Since this factor is generally credited with confounding the results of aging studies, it was felt appropriate to analyze the influence of amount of education. Correlations were therefore computed between years of formal education and the PMA and TBR scores. These are listed in Table 14.

It is apparent from Table 14 that years of education are significantly related to most of the variables studied, but few or no significant age trends are noted. Education seems to be related most significantly with the psychomotor speed score. One would infer from this observation that one of the principal effects of added years of education might be to add to one's ability to emit familiar responses without hesitation. Education seems thus more important in facilitating the handling of known data than in influencing a person's ability to handle new learning or unfamiliar situations. There is, however, a mild correlation between the measures of motor-cognitive and personality-perceptual rigidity and education. Education shows, as would be expected, moderately positive correlation with the composite IQ scores.

The next step in the analysis of the influence of education was to compute partial correlation coefficients between the TBR scores and the composite IQ with the effect of education held constant.

TABLE 15

CORRELATIONS BETWEEN THE COMPOSITE IQ AND THE TBR SCORES ADJUSTED FOR THE EFFECT OF YEARS OF EDUCATION

Age	MCR	PPR	PS	COMP
20–25	.39	.13	.56	.55
26–30	.43	.13	.61	.61
31–35	.45	.26	.44	.57
36–40	.30	.27	.58	.64
41–45	.40	.38	.63	.68
46–50	.49	.19	.51	.55
51–55	.35	.17	.24	.40
56–60	.16	.15	.54	.56
61–65	.31	−.15	.21	.20
66–70	.45	−.02	.47	.50

Table 15 lists these partial correlations and Figure 7 shows the new age gradients plotted with these adjusted correlation values. It can be seen that adjusting for the effect of differences in years of education merely tends to reduce all correlations somewhat but has little or no systematic effect on the slopes of the age gradients.

The Test of the Principal Hypotheses: Results of the Analysis of Variance and Covariance.

The final part of this section is concerned with the formal statistical test of the hypotheses by means of the analysis of variance and covariance. The methods used are those described by Edwards (5).

The analysis of variance was used as a first step to test the null hypothesis with respect to the significance of the differences between age groups on both the TBR and PMA scores. Since the *T* scores were used for these computations, the sums of squares for the different variables, as summarized in Table 16, are directly comparable. All *F* ratios are, of course, found to be highly significant.

The next step in this analysis is concerned with the test of the hypotheses suggested by the rigidity-flexibility model. If Case I is true, one should find that age changes on the PMA are reduced to nonsignificance when the means are adjusted for level of rigidity, since the hypothesis tested proposes that age changes in intellectual abilities are a function of the differences in level of rigidity. The null hypothesis states that if changes in intelligence can be accounted for on the basis of changes in rigidity, then the *F* ratio between the ad-

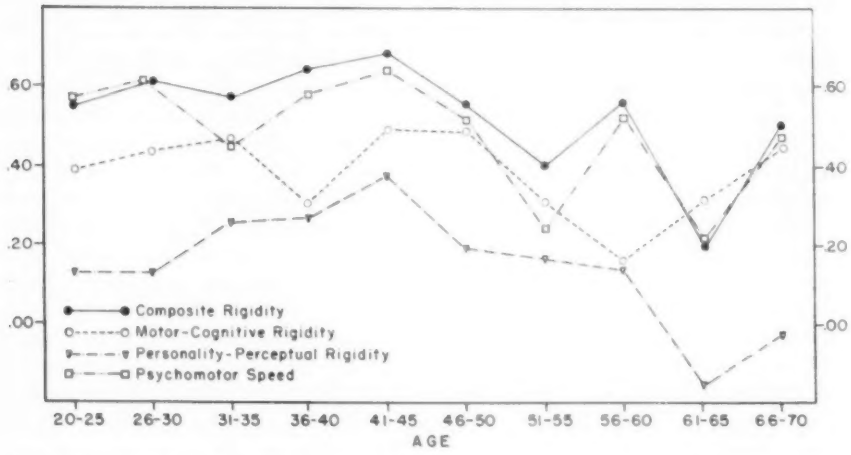


FIG. 7. Correlation between TBR scores and PMA composite IQ (effect of education partialed out).

TABLE 16

RESULTS OF THE ANALYSIS OF VARIANCE TESTING THE SIGNIFICANCE OF THE DIFFERENCES BETWEEN AGE GROUPS ON THE TBR AND PMA SCORES

Variable	Between-group variance	Within-group variance	*F* ratio[a]
Composite rigidity	671.86	27.95	24.04
Motor-cognitive rigidity	575.19	46.83	12.28
Personality-perceptual rigidity	529.11	53.88	9.82
Psychomotor speed	666.20	68.76	9.69
Composite IQ	1,215.81	79.57	15.28
Verbal-Meaning	1,202.55	79.91	15.05
Space	1,220.22	91.11	13.69
Reasoning	1,603.27	72.61	22.08
Number	448.70	93.95	4.78
Word-Fluency	517.37	92.61	5.59

[a] With 9 and 490 degrees of freedom respectively, an *F* ratio will be significant at the 1% level of confidence if it exceeds 2.45.

justed variances should be a chance deviation from zero. Table 17 summarizes the results of the analysis of covariance for the regression of the composite IQ upon the TBR composite and factor scores and also, as a reverse test of possible evidence for the validity of Case IV, for the regression of the composite IQ score on the TBR composite score. With 9 and 489 degrees of freedom respectively, an *F* ratio is significant at the 1% level of confidence if it exceeds 2.43. Every *F* ratio in Table 17 is therefore significant, and the null hypothesis as stated is not verified.

TABLE 17

RESULTS OF THE ANALYSIS OF COVARIANCE TESTING THE EFFECT OF THE REGRESSION OF THE COMPOSITE IQ SCORE UPON THE TBR SCORES AND OF THE COMPOSITE RIGIDITY UPON THE IQ SCORE

Variable	Adjusted between-group variance	Adjusted within-group variance	*F* ratio
Composite rigidity	150.24	48.61	3.09
Motor-cognitive rigidity	535.78	63.31	8.46
Personality-perc. rigidity	744.55	75.14	9.91
Psychomotor speed	847.88	49.52	17.12
Composite IQ	175.95	17.08	10.30

TABLE 18

RESULTS OF THE ANALYSIS OF COVARIANCE TESTING THE EFFECT OF THE REGRESSION OF THE INDIVIDUAL MENTAL ABILITIES UPON THE COMPOSITE RIGIDITY SCORE

Variable	Adjusted between-group variance	Adjusted within-group variance	*F* ratio
Verbal-Meaning	190.10	51.52	3.69
Space	436.54	85.47	5.11
Reasoning	284.41	50.81	5.60
Number	315.51	76.54	4.12
Word-Fluency	166.30	71.29	2.39

Comparison of Tables 16 and 17 shows that the maximum reduction in the *F* ratios, by adjusting the means for the effects of correlation, occurred for the composite rigidity score. As a further check, the analysis of covariance was therefore used to test the effect of the regression of the individual mental abilities upon the composite rigidity score. Table 18 lists the results of this analysis, which show reduction in the *F* ratios which, however, remain significant. The null hypothesis may thus also be rejected for the individual mental abilities.

As a result of the correlation analysis it appears that Case II is the more plausible one. Hypothesis II required that there be substantial correlation between rigidity-flexibility and intelligence at each age level and that prediction of intellectual functioning would be possible from a knowledge of rigidity scores. In order to obtain further evidence for the validity of the second alternative, the records for the *Ss* in each age group were rank ordered in terms of the composite rigidity score. The 10 most flexible and the 10 most rigid subjects in each age group were then selected and mean values were computed for these extremes on

TABLE 19

MEANS ON THE PRIMARY MENTAL ABILITIES FOR THE EXTREME FLEXIBLE AND THE EXTREME RIGID MEMBERS OF THE SAMPLE

	Age	20–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70
V	r	44.5	48.0	46.3	41.8	43.2	43.0	41.2	43.4	34.9	34.5
	f	57.1	61.3	60.5	58.8	61.5	60.5	55.8	54.8	44.3	48.5
S	r	53.8	51.5	48.8	51.0	47.9	48.4	43.0	44.2	44.2	38.3
	f	61.0	57.3	57.5	58.2	56.8	54.6	53.0	49.0	42.7	40.0
R	r	49.4	49.8	47.9	44.2	49.0	42.4	42.0	39.2	37.3	36.9
	f	65.6	63.8	59.0	61.5	58.6	54.8	56.1	52.0	47.5	43.5
N	r	42.8	40.8	42.0	41.0	47.4	46.1	48.8	48.9	43.3	39.1
	f	57.9	57.5	54.0	61.0	56.4	60.9	58.4	56.8	47.0	50.9
W	r	46.0	43.2	46.4	41.7	46.6	43.4	45.1	41.0	37.9	41.7
	f	61.2	53.4	56.5	52.8	58.9	58.8	58.5	58.4	52.1	46.4
IQ	r	45.7	46.4	44.6	41.5	46.2	43.2	43.1	42.0	36.9	35.0
	f	63.4	60.0	59.0	61.2	59.6	61.0	58.7	56.0	46.2	45.6

the measures of mental ability.

While there are some age trends in the differences between the flexible and rigid groups, these differences appear to be significant at all ages and for all abilities. Differences range from one-half to two population *SD*s. When mean differences are computed for the extremes for the total population, they are found to be in excess of 1.0 *SD*, except for Space which shows a mean difference of 0.6 *SD*. Table 19 lists the mean values for the extreme flexible (f) and extreme rigid (r) subgroups, classified by age.

Table 20 lists the absolute differences in *T*-score points, all of which are significant at the 1% level of confidence, except the differences for the two oldest age groups on Space. There is a tendency for all these differences to be more pronounced in the middle years, with increasing convergence towards the upper end of the age continuum. It appears that, due to the fact of general decrement in abilities, the range of talent becomes more restricted in the older age groups. However, significant differences in the various abilities are maintained between the rigid and flexible individuals throughout the age range. This evidence would seem to favor Hypothesis II and lead to a rejection of the null hypothesis with respect to Hypotheses I, III, and IV.

TABLE 20

DIFFERENCES IN THE MEAN SCORES ON THE PRIMARY MENTAL ABILITIES FOR THE EXTREME RIGID AND FLEXIBLE GROUPS (IN *T*-SCORE POINTS)

Age	20–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70
V	12.6	13.3	14.3	17.0	18.3	17.5	14.5	11.4	9.4	14.0
S	7.2	5.9	8.7	7.2	8.9	6.2	10.0	4.8	−1.5	1.7
R	16.2	14.0	11.1	17.3	9.6	12.4	14.1	12.8	10.2	6.6
N	15.1	16.7	12.0	20.0	9.0	14.8	9.6	8.0	3.6	11.8
W	15.3	10.3	10.1	11.1	12.3	15.4	13.4	17.4	14.2	4.8
IQ	17.7	13.6	14.5	19.7	13.3	17.8	15.6	14.0	9.2	10.6

Discussion

More than anything else, it would seem that the evidence on concomitant age changes both in the rigidity and intellectual measures gives support to the school of thought which sees decline as a maturational phenomenon which occurs at a relatively constant rate and whose degree is presumed to be a function of original endowment. In the case of the mental abilities, this interpretation would seem to be reinforced by the findings of decreasing response variability with increasing age.

The results of the present study suggest that both rigidity-flexibility and measures of mental ability may be useful to predict level of functioning at any given age level. There was little support, however, for the contention that either dimension may be used for the long-range prediction of specific age gradients in other behavior characteristics. While one cannot use rigidity-flexibility to predict absolute decline, the relationships found may be used to make predictions about the relative rank an individual is likely to attain at a later age.

Although measures of three distinct rigidity dimensions were used, it appears that a linear combination of these factors had the best predictive power and that such a composite score discriminated best on other variables. While there is a great deal of overlap about the mean of this score, it was found that at the extremes flexible individuals excelled the rigid with respect to many behavior and personal characteristics.[7] This finding seems to imply that a composite rigidity measure, combining estimates of the several dimensions used to define rigidity, is a useful and discriminating tool.

The rigidity-flexibility dimension was found to be of almost equally discriminative power throughout the adult age range, even though restriction of the range of observed rigidity measures occurred at the upper age levels. This finding might be interpreted by suggesting that the rigidity measures may give an indication of how well an individual is able to make use of his capacities. Thus an individual who scores high on the TBR probably makes effective use of his capacities, while one who scores low does not. No direct evidence on this point is given in this study, however, and one would probably have to define independent indices of optimal functioning to be correlated with our rigidity measures for further evidence.

It was noted that, among the rigidity factor scores, the ones showing highest relations with other measures were the motor-cognitive rigidity and the psychomotor speed scores. These scores presumably are indices of the difficulty in adjusting to change in familiar tasks and the ability to emit familiar responses and were expected to correlate best with the measures of cognitive behavior. The personality-perceptual rigidity score showed only low correlation with the cognitive material, but its inclusion in the composite score raised the predictive power of the latter.

Because of the high correlations between measures of intelligence and of rigidity an analysis of the predictive power of extreme scores was attempted also in terms of the composite intelligence measures. This analysis showed that discrimination occurred also at the younger ages, but convergence of the mean flexibility-rigidity scores for the

[7] The extreme flexible subjects were found to exceed the extreme rigid in a positive direction in education, income, occupational status, social responsibility, and other variables (24).

extreme low and high intelligence groups was seen in middle age. This finding would seem to be further evidence against Hypothesis IV and would suggest that at least in the older age groups the rigidity-flexibility scores are better indicators of effective functioning and have more predictive power than performance on the intelligence test. The results of these extreme splits for both rigidity-flexibility and intelligence suggest that optimal functioning at young maturity and during the middle years may involve the interaction of both flexibility and intellectual level, while at the older ages maintenance of flexibility increases in importance.

In terms of the long-range prediction of behavior, it seems safe to conclude that this study presents additional evidence to show significant age decrements in important aspects of behavior. Considerable differences are also shown to exist among different measures as to their peak age of performance, the slope of the decrement gradient, and the variability of individuals at given age levels. It is of considerable interest to note that the peak levels found in the present study come at later ages than those found in the cross-sectional studies of the 1930's. Not enough time seems to have elapsed, however, to attribute these differences entirely to cultural changes, and the different tests used may be at least partially responsible for these findings.

On the basis of these findings with respect to differing peak ages for different abilities, it may be suggested that the adult plateau shown by global measures of intelligence would seem to be caused by the fact that during this period growth still occurs in some abilities while decline has already set in with others. The point where steep and behaviorally significant decrement begins occurs at that age where growth has ceased in all the abilities which are measured to yield the intelligence estimate. Likewise it may be suggested that the findings of different variability at given ages, for different measures of ability, may account for the apparent differences in the rate of decline of individuals. These differences may well be a function of their attaining a peak level of development at different points.

From the age gradients presented for both the measures of rigidity and mental ability it would appear that, in general, an individual's status at a given age will be a function of his original peak level. Knowing the individual's basal level and the average age changes observed in the population, one might then be able to make a rough prediction as to what his level of performance is likely to be at a later age. Further work is needed, however, to determine the effect of differential basal levels.

Summary

1. An analysis was made of studies of developmental changes in adult behavior, and explanatory models using the concept of behavioral rigidity were considered.

2. Alternative models for the relationship between developmental changes in intelligence (as measured by the Primary Mental Abilities) and measures of rigid behavior were formulated. Case I stated that maintenance of intellectual ability is a function of "flexibility," in which case a positive and systematically increasing relationship between measures of intelligence and rigidity-flexibility would occur with increasing age. Case II stated that both intellectual ability and behavioral rigidity show concomitant age changes, in which case either might be predicted by the other, and that a high

positive relationship should be found throughout the adult age span, with somewhat decreasing correlations due to the restriction of range in the older age groups. Case III stated that, while age changes in the mental abilities and rigidity-flexibility occur, they would show no systematic relation and zero or spurious correlation would be expected. Case IV finally involved the falsification of Case I, namely that maintenance of flexibility is a function of intellectual ability.

3. A sample of 500 adults ranging in age from 20 to 70 years, subdivided into five-year age groups, each containing 25 men and 25 women, was drawn from a pool of about 18,000 potential subjects who were members of a prepaid medical plan and were reasonably representative of a large portion of the socioeconomic continuum.

4. The subjects were tested with Thurstone's SRA Primary Mental Abilities Test and with Schaie's Test of Behavioral Rigidity. Information was also obtained on measures of family status and socioeconomic level.

5. Significant age differences were found on all measures of mental abilities and behavioral rigidity. There was considerable difference in the decrement shown on the different measures, in the ages of peak performance for the different abilities, in the changes in variability, and in the rate of decline.

6. Correlations between the measures of rigidity and mental ability and an analysis of variance and covariance were used to test the principal hypotheses. The correlations between the measures of rigidity and the mental abilities were found to be significantly high throughout the adult age span with a tendency to decrease towards the upper end of the age continuum. When the analysis of covariance was used to adjust the between-group differences on the mental abilities for the effect of rigidity, significant differences remained.

7. On the basis of this evidence neither Case I nor its obverse Case IV were verified, but Case II which favors interaction between rigidity-flexibility and intelligence at every age level seems to be supported.

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